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ADJUSTMENT OF A HEARING AID USING A PHONE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to the field of hearing aids and, more particularly, to the use of an existing phone to automatically reconfigure or readjust the performance of a hearing aid.

2. Description of the Related Art

The human auditory system processes sounds from a complex 3-dimensional space via the external, middle, and inner ear, as well as via the complex neural pathways that lead to the auditory cortex within the brain. A measurable hearing loss, due to various conductive, sensorineural or central auditory disorders, affects a significant percentage of the human population, particularly elderly persons. Rehabilitation via hearing aids remains the only viable option for those types of hearing impairments that cannot otherwise be medically treated or surgically alleviated.

Conventional hearing aids are analog or digital devices which filter and amplify sound. The frequency response of the filter can be configured to compensate for the frequency-dependent hearing loss of particular users, e.g., as determined by an audiogram. More

sophisticated hearing aids can compress the dynamic range of detected sounds amplifying softer sounds below the threshold of hearing while maintaining loud sounds at their usual levels so that they do not exceed the threshold of discomfort. This compression of dynamic range may be performed separately in different frequency bands.

The custom configuration of a hearing aid, typically performed by an audiologist or hearing aid dispenser, involves selecting the frequency response of the aid as a function of a user's audiogram. However, there are a large number of different programming possibilities which result from the number of available hearing aid types and the many hearing aid parameters that can be varied by control elements or by programming, including elements such as frequency response (for example, edge/shift edge steepness in the base and treble range), gain, cut-off point of the Automatic Gain Control ("AGC") peak clipping, etc. The large number of programming possibilities has resulted in the situation where the time expenditure required to run through the numerous possibilities to arrive at an optimum adaptation is no longer justifiable

Typically, an audiologist or hearing aid dispenser matches the performance characteristics of a conventional hearing aid to the hearing characteristics of a user before delivering the hearing aid to the user. In particular, the audiologist or hearing aid dispenser measures the hearing characteristics of the user, e.g., during an office visit and generates an audiogram representing the measured hearing characteristics. Next, the provider fits the device characteristics to the audiogram. This is typically performed after the customer has left because of the length of time involved. Finally, the adjusted hearing aid is delivered to the user.

Due to the effects of aging or other environmental factors, a person's quality of hearing may vary over time. As a result, a customized hearing aid may require periodic

adjustments to take into account changes in the user's hearing characteristics. This adjustment requires the user to remove and return the hearing aid for refitting or to travel to the audiologist or hearing aid dispenser where the fitting process can be performed. Both situations entail a considerable inconvenience, depending on where the user and the audiologist or hearing aid dispenser are located. Furthermore, if the user mails the hearing aid to the audiologist or hearing aid dispenser for fitting, the user will be without their hearing aid while the fitting is being performed. Moreover, without having the user present during the fitting, at best the fitting will be an approximation of the user's hearing characteristics limited by the accuracy of the audiogram.

Accordingly, there is a need and desire to minimize the drawbacks associated with adjusting the hearing aid to compensate for changes over time in the hearing characteristics of a user.

SUMMARY OF THE INVENTION

The present invention is a system and method for using a telephone to reconfigure or readjust the performance characteristics of a hearing aid or to check whether a user has a hearing problem. A conventional telephone network connection has a bandwidth of 300 Hz to 4 KHz. However, many telephones contain components which generate frequencies which exceed this narrow bandwidth. In particular, many modern telephones contain a sophisticated digital signal processor (DSP) which can be programmed to perform operations, such as generating tones or frequencies ranging from 300 Hz to 20,000 Hz, for use in performing audio tests.

In accordance with the present invention, the telephone is used to generate one or more frequency tests covering the audible spectrum using the DSP contained in the phone and/or an external computer. Alternatively, the DSP may be located in the hearing aid and is controlled

by a digital link from the telephone or external computer by an acoustical, infra red, RF or physical link. The keypad of the phone may be used as a feedback mechanism. The generated frequencies can be used to test the hearing of a user and the quality (or fit) of a hearing aid while being worn by the user.

A local memory may be used to store the results of the tests for future reference or for transmission over the telephone network for analysis at a later time. Once the hearing response of a user wearing the hearing aid has been measured, an updated compensation configuration (audiogram) can be downloaded into the hearing aid via a wireless link, such as an infra-red, RF, or acoustic link, or via a physical connection, for example, a modem connected to the telephone network.

Advantageously, the testing may be performed at a user's home and the results automatically sent to the audiologist or hearing dispenser for later analysis. Moreover, a history of measurements may be used to indicate additional problems in the hearing of a user.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other advantages and features of the invention will become more apparent from the detailed description of the preferred embodiments of the invention given below with reference to the accompanying drawings in which:

Fig. 1 is an illustration of a system for implementing the method according to the invention;

Fig. 2 is an illustration of a closed loop system for implementing the method according to the invention;

Fig. 3 is an illustration of the system of Fig. 1 with a DSP located in a hearing aid;

Fig. 4 is illustration of the closed loop system of Fig. 2 with the DSP located in the hearing aid; and

Fig. 5 is a flow chart which illustrates the steps of the method according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the invention is shown in Fig. 1. In the illustrated embodiment, the system comprises a programming device, such as a personal computer **10**, which is equipped with a keyboard **17** or other input device. The computer **10** is connected to a hearing aid **11**, whose transmission characteristics are to be adapted by a data link **12,** such as a hard wire link, a wireless link such as an infra-red, RF, magnetic, or acoustic link (not shown). The computer **10** is additionally connected to a telephone **13** which contains a DSP **18**. Keyboard **17** is used by a user of the system to implement responses to inputs from an audiologist or hearing aid dispenser. Alternatively, the telephone keypad **19** can be used as a user input device.

In communication with the computer **10** via a remote data link **14** (a direct dial-up connection via a modem, for example) is a diagnostic computer **15** having a keyboard **16** for inputting test tone commands from the audiologist or hearing aid dispenser. In accordance with the invention, an audiologist or hearing aid dispenser sends a command (for example, a DTMF tone which indicates pitch, volume and duration) for transmission via a diagnostic computer **15** at a first location. The command is then transmitted over the remote data link **14** to the test computer **10** at a second location. This command is sent from the test computer **10** to a DSP **18**

in a telephone **13** while the user is listening to the phone. A test tone is then generated from the DSP **18** based on the output command and is received by the user of the telephone **13** who is wearing the hearing aid. In response to the received tone, the user then enters a response to the test tone on the keyboard **17**. This response is transmitted back to the diagnostic computer **15** over the remote data link **14**, where a test using a computer program is performed to determine whether or not the user correctly responded to the generated tone. This can be repeated at a number of frequencies over the audio range.

If it is determined that the user did not respond to the tones correctly, an updated compensation configuration (audiogram) is calculated in computer **15** and is downloaded into the hearing aid by the audiologist. Alternatively, an updated compensation configuration (audiogram) may be automatically downloaded using the computer program. The hearing test is performed across the expanded frequency spectrum in the range from 300 Hz to 20 KHz. In this manner, the quality (or fit) of a hearing aid, while being worn by a user, may be tested.

Instead of using local the computer **10**, the entire testing operation can be set up using phone **13** connected to the data link **14**, which may be a telephone line. The computer **15** sends messages over the phone line directly to the DSP **18** in the phone. This causes it to respond by creating a series of tones over the audio spectrum. The user of the hearing aid **11** responds to these tones by using the keypad **19** on the phone. The responses are sent to computer **15** where they are stored for later use by the audiologist.

The information thus gathered can be stored in the diagnostic computer **15** for later retrieval by an audiologist or hearing aid dispenser. Alternatively, the test may be performed at the user end of the network **14** using only the computer **10** in an off-line manner. The preceding

tests are performed using algorithms which are stored in the computer **10** and diagnostic computer **15**. The hearing aid **11** may also be removed from the ear of the user and manually adjusted.

An alternative embodiment of the invention is shown in Fig. 2. In this case, the hearing test is performed in a closed loop system which comprises the telephone **13** containing the DSP **18**, the hearing aid **11** and computer **10**. Here, the computer **10** is shown as being external to the telephone **13**. However, in the present embodiment, the computer **10** may also be integrated into the telephone **13**. To perform the hearing test, commands are sent from the computer **10** to the DSP **18**. In response to the commands, the DSP **18** generates frequency tones which a user listens to. A hearing test is administered to the user across the expanded frequency spectrum in the range from 300 to 20 kilohertz. Responses to the test tones are input on the keyboard (not shown) of the telephone **13** or on the keyboard of the computer **10**. Once the user has completed the test, the results can be stored for subsequent diagnosis by an audiologist or hearing aid dispenser.

In the present invention, as shown in Fig. 3 and Fig. 4, the DSP **18** may be located in the hearing aid **11** (instead of, or in conjunction with, the DSP **18** to in the telephone **13**). In this configuration, the hearing test is performed in the manner described previously. However, the commands are sent to the DSP **18** via the telephone **13** in Fig. 4 or computer **10** in Fig. 3. In response to the commands, the DSP **18** then generates the frequency tones which the user wearing the hearing aid **11** listens to. The hearing test is administered to the user across the expanded frequency spectrum in the range from 300 to 20 kilohertz. Responses to the test tones are input on the key pad **19** of the telephone **13** or on the keyboard **17** of the computer **10**. As

before, once the user has completed the test, the results can be stored for subsequent diagnosis by an audiologist or hearing aid dispenser.

Figure 5 is a flowchart depicting the steps of the method according to the invention. In a first step **101**, an audiologist or a hearing aid dispenser generates a tone which is transmitted over a network **14**. On the opposite end of the network, in step **102**, a user wearing the hearing aid enters a response to the generated frequency tone. Steps **101** through **103** are interactively repeated until a hearing test along the entire expanded range of frequencies has been performed. In step **104**, the responses entered by the user are checked to determine whether or not they are appropriate responses. If the responses to the generated tones are correct, then the process is terminated. On the other hand, if any of the inputted responses are incorrect, then in step **105** a new compensation configuration is computed and uploaded into the hearing aid **11**. In this manner, the hearing aid is adjusted such that a custom fit based on the present hearing characteristics of the user is achieved.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example, and is not to be taken by way of limitation. The spirit and scope of the present invention are to be limited only by the terms of the appended claims.